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FARTHER, HIGHER AND QUIETER

by

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ABSTRACT

(U) Present day requirements on a limited noise factor were taken into consideration in the design and construction of the Il-62 aircraft. This was accomplished by using turbofan engines with a comparatively low exhaust velocity of the jet stream and special piloting techniques during takeoff. The NK-8 turbofan engines mounted on the Il-62 have a by-pass ratio approaching m equals 1. Therefore, under takeoff conditions of operation the noise from the principle sources is just about the same. To decrease the noise produced in the immediate vicinity, the takeoff of the Il-62 is performed in the following manner: 1) After liftoff, at a height of 5 to 8 m, the landing gear is retracted. Simultaneously the aircraft accelerates and climbs. The speed is maintained up to H equals 150 m. 2) During acceleration above 150 m, the flaps are retracted from 30 to 15 degrees. The climb to an altitude of 800 m is accomplished with 15 degrees flaps and at a constant speed of 310 to 345 km/hr, depending upon the take-off weight of the aircraft. 3) At an altitude of 800 m in the process of acceleration, the flaps are fully retracted in such a manner that this operation is completed at the moment the aircraft attains a speed of 400 km/hr. The principle behind this method of take-off is described in some detail. Graphs and tables are used to illustrate the article. A comparison is made between the Il-62, Tu-104, Tu-124, Boeing 707-320, Caravelle-3 and Comet-4. Orig. art. has: 3 figures and 3 tables.

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FARTHER, HIGHER AND QUIETER

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The pages of our magazine were not the first in which questions connected with the investigation and development of measures for noise reduction in airliners were discussed. It is enough to remember the articles "Characteristics of the noise created by the TU-104 aircraft," "New investigations of TU-104 noise during takeoff," "An adjustable noise suppressor" and "Pilots and acoustics" [Grazhdanskaya aviatsiya, No. 2 and No. 6, 1958; No. 10, 1960; No. 2, 1967]. The growth in the number of aircraft, the increase in the intensity of their use, the rise in the number of airports and in the population density in their vicinities and the approach of city boundaries toward airports aggravate the problem even further. Therefore, as was noted at the international conference held in London at the end of 1966, noise problems actually occupy second place after flight safety assurance.

This article is a short discussion of the report "The characteristics of the takeoff noise of the IL-62 airliner" prepared by the Civil Aviation State Scientific-Research Institute together with the S. V. Ilyushin Design Office.

To a certain extent, noise in the areas of giant airports is the price paid for the possibility of overcoming huge spaces at high speed and comfort. It is considered that the general growth of noise is an unavoidable consequence of technological progress. It would nevertheless be logical to assume the opposite: technical progress,

intended to serve the interests of mankind, should lead to less noise.

The IL-62 aircraft has been designed and built with consideration of modern requirements for noise restriction. To what is its successful reduction due? There are two such factors: the use of turbofan jet engines with a comparatively low jet-stream exhaust velocity (the acoustic power emitted by the jet is proportional to the exhaust velocity to the eighth power) and the use of a special method of piloting during takeoff.

Aircraft noise is usually characterized by perception levels, designated as PNdb. In distinction from decibels these units not only consider the emitted acoustic power but also the fact that at the same level noises of different frequency composition affect people in different ways.

Figure 1 shows the dependence of the maximum noise of flying aircraft with turbojet engines (TJE) and turbofan engines (TFE) on their operating conditions. For a single-shaft TJE the fan noise, as a rule, is insignificant in comparison to the jet noise. It increases in proportion to the increase in the degree of turbofan state of the

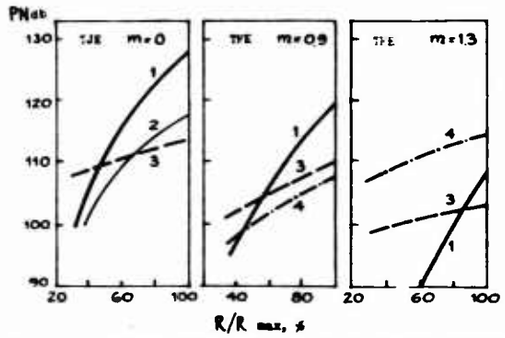

Fig. 1. Dependence of maximum basic-source noise of flying aircraft with TJE and TFE on their operating conditions (as per cent of maximum thrust). Conditions: an aircraft with four engines "Evon," "Spey" and JTZD

type, respectively, whose thrust is reduced to one value; the altitude of flight is 320 meters and speed is 300 km/h.
1 – Jet noise; 2 – jet noise with the use of a noise suppressor; 3 – turbine noise; 4 – fan noise.

TFE. The NK-8 TFE installed in the IL-62 have a turbofan level close to m = 1. Therefore, its basic source noises during takeoff are approximately identical. During descent the turbine is usually the noise source. The development of methods for suppressing it is one of the basic problems of aviation acoustics.

The method of "low-noise" takeoff includes elements such as the execution of a steeper climb (obtained by maintaining a constant velocity equal to V_{bez} + (20-30 km per hour)), the engine regime reduction above a populated area, and the execution of a chandelle in a direction away from populated points.

For suppressing noise created in the vicinity the takeoff of the IL-62 proceeds in the following manner:

1. The landing gear is retracted after liftoff at an altitude of five to eight meters. At the same time the aircraft accelerates and gains altitude. Up to H = 150 m the velocities below are maintained:

Takeoff weight, t	150 and below	140	130	120
Indicated air-speed, km/h	300	310	320	330

2. After the plane has attained a height of 150 meters during acceleration the flaps are retracted from 30 to 15 degrees. With the flaps positioned at 15 degrees a climb of 800 meters is executed, at a constant speed of 310-345 km/h, depending on aircraft takeoff weight:

Takeoff weight, t	120 and below	140	130	100
Indicated air-speed, km/h	310	320	330	345

3. At an altitude of 800 meters during acceleration the flaps are completely retracted with the idea that this operation is completed

before the aircraft speed reaches 400 km/h. The engines still operate under takeoff conditions.

Typical trajectories of the initial climb by the described method during the takeoff of an IL-62 with varied weight under standard atmospheric conditions and calm are given in Fig. 2. Since meteorological conditions basically influence the trajectory, and consequently the noise, the concept of a "reduced" weight of the aircraft is introduced. It is determined from the diagram which considers the true takeoff weight and such weather factors as air temperature and ground wind velocity. For example, if the takeoff weight is equal to 152.5 tons, the air temperature plus 25 degrees centigrade and the wind ground-speed component is 2.5 meters per second, the assumed weight amounts to 157.5 tons. Knowing the distance to the populated point, we can, from the graph in Fig. 2, calculate the flight altitude and expected noise level (shown by the dashed line).

During government testing of the IL-62 noise characteristics were investigated by the methods and recommendations of the International Organization of Standardization R507 by means of an acoustic device of the Bruel and Kjaer Company. Maximum noise spectra were obtained by analyzing magnetic recording of noise under laboratory conditions with an averaging of the sound pressure levels in each octave band of frequencies measured at the moment of time corresponding to the maximum of the total level. The levels of the perceived noise were calculated from the spectra obtained in this manner.

A comparison of the noise of the IL-62 and that of other aircraft is of interest. For the IL-62 at an altitude of 300 meters, standard for a flight during the takeoff of heavy machines over an inhabited area, the level of perceived noise reaches 112.5 PNdb during full-power engine operation. Modern foreign airliners with TFE create the same or more intense noise: DC-8-50, approximately 114.5 PNdb; DC-8-55 and DC-8-61, approximately 119.5 PNdb; Convair 990, 118 PNdb; and Caravelle 10A (10B), 111.5-112.5 PNdb. For such aircraft with TJE as the Boeing 707-120, 707-320, Boeing 720, the DC-8-10 (20, 30, 40), Caravelle-3, 6N, and 6R, and the Convair 880, equipped with noise suppressing nozzles, these levels are considerably higher and vary

within the limits of 118-122.5 PNdb. The noise level of the TU-104 aircraft with TJE without noise-suppressing nozzles amounts to 121 PNdb.

In flight over populated areas noise can be reduced by throttling the engines to the point which assures the continuation of the climb with a vertical speed of not less than 2.5-4 meters per second. For For TJE aircraft the noise is lowered to 105-112 PNdb. As a rule, the effectiveness of this method in reducing the noise of TFE aircraft is lower; in some cases, when the fan exhaust noise is the determining factor (the JT3D Pratt and Whitney TFE, widely used in modern heavy airliners), hardly any effect is observed in a wide range of operational conditions.

A comparison of noise levels located at a checkpoint six kilometers from the beginning of the takeoff run in the takeoff of different aircraft is shown in the table (takeoff weight is maximum, piloting is with the maintenance of a constant speed, international standard atmosphere, calm):

Type of aircraft	Altitude of flight over checkpoint, m	Level of perceived noise, PNdb	
		Engines at full-power operation	With reduction of engine regime
IL-62	300	112.5	–
TU-104	300	118	107
TU-124	270	108	98
Boeing 707-320	300	120	111
Caravelle-3	300	113	103
Comet-4	630	111	106

Thus, in takeoff noise the IL-62 has definite advantages over other Soviet and foreign aircraft. Further noise reduction is possible by throttling the engines in takeoff. The effectiveness of this method is being investigated. Noise during the descent of the IL-62, as has been shown by preliminary investigations, reaches 117 PNdb at a distance of one and a half kilometers from the end of the runway, which is close to levels created by modern jet aircraft.

The qualities of the IL-62 are obvious from the standpoint of the load capability of its structural elements. The use of TFE and their position in the tail section of the aircraft permit decreasing the intensity and the area of the interaction of the acoustic pressure in

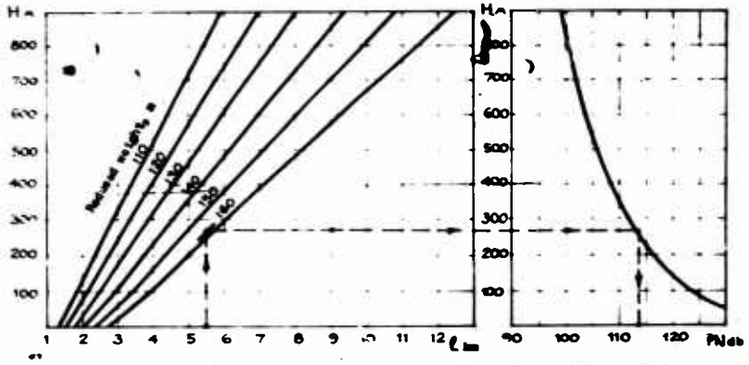

Fig. 2. The trajectories of climb, and the noise created in the vicinity during the flight of an IL-62 (conditions: international standard atmosphere and calm; the weight shown corresponds to the true takeoff weight).

the engine exhaust zone. The total measured acoustic pressure levels near the tail unit during full-power engine operation does not exceed 144 db (an absolute total pressure of 32 kg per square meter). In aircraft with TJE the acoustic loads under similar conditions, as is known, reach 155-160 db (115-204 kilograms per square meter).

Summary

In terms of noise level, one of the most important characteristics of modern aircraft, there are no obstacles to the successful use of the Soviet IL-62 aircraft in all of the largest airports in our country and in the entire world.